Spatial Analysis of Seasonal Changes of Vegetation Cover in Selected Areas of Najaf Governorate Using Geographic Information Systems and Remote Sensing Techniques

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Abstract: *The current study aims to reveal the spatial and temporal changes of the vegetation cover for both the spring and autumn seasons, by taking advantage of the integration between remote sensing techniques and geographic information systems, utilizing the Landsat 8 images for the years 2014 and 2022, detecting the most important changes that occurred during this period. The NDVI index was adopted to map vegetation cover and calculate their area for each season, also comparing the change in the areas at the seasonal level for the years 2014 and 2022, as well as one season and another for the same period. The results indicated that there are changes in the area of vegetation cover, whether on the seasonal or annual level. The results of the study also showed that there is a clear and significant deterioration in the area of vegetation cover during the autumn of 2022, whether when compared with the area of vegetation cover in the spring of the same year or the spring and autumn seasons of 2014.*

Keywords: *Landsat8 , NDVI, Vegetation cover, Najaf, Iraq.*

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Introduction

The meaning of vegetation cover is the amount of land covered by plants of any type, which is the result of the overlap and interaction between many factors, including natural factors and human factors [1]. The state of vegetation cover is an important indicator of environmental deterioration [2]. The studying of the vegetation cover state and observing its changes, whether positive or negative, is one of the important topics that have contact with people's lives, especially with the increase in population growth and the increase in demand for foodstuffs [3]. The vegetation cover is one of the most important natural wealth and resources, especially in arid and semi-arid ecosystems, which do not have the ability to restore their balance without the intervention of the human factor [4].

Remote sensing techniques and geographic information systems are among the advanced techniques that have been used a lot in classifying vegetation in order to identify its characteristics and geographical distribution [5]. These techniques are characterized by their efficiency and ability compared to traditional methods by providing visual historical records for any region [6]. The use of spectral indices is one of the best means to classify and monitor land covers, including vegetation cover, as the vegetation index is one of the most popular spectral indices used to detect vegetation in terms of its density, health, and spread [7]. The work of spectral indices depends mainly on dividing the reflectivity values of one band by the

corresponding values in the other band, thus clarifying the spectral reflectance curve of the two bands, regardless of the reflectance values absorbed by the spectral bands [8]. With regard to the vegetation index, its work depends on measuring the reflection rate for both the near-infrared (NIR) and red (R) bands, and depending on the spectral characteristics of the plant. In the red band, it depends on the chlorophyll content, while in the near-infrared band, it depends on the structure of the internal structure of the plant cell, in addition to other plant characteristics in terms of vegetation, biomass, physical characteristics, etc. [9].

The current study aims to employ automated processors of Landsat satellite images through the use of the vegetation index and change detection tools in order to know the seasonal effects on the vegetation cover between two different seasons (spring and autumn) and on both the seasonal and annual levels for the period from 2014 to 2022.

Study Area

In Iraq, the Al-Najaf governorate is a well-known and significant region [10,11]. The study area is located in the northeastern part of Najaf Governorate, bordered by Karbala Governorate from the northeast northwest, Babel Governorate from the northeast, and Al-Qadisiyah Governorate from the east, and between longitudes 43° 40' and 44° 40' E, latitudes 31° 35' and 32° 21' N. The study area includes both the Najaf center district, Al-Haydariyyah district, Al-Kufa center district, Al-Hurriyah district, and Al-Hira district, with an area of 3690 km^2, Figure (1).
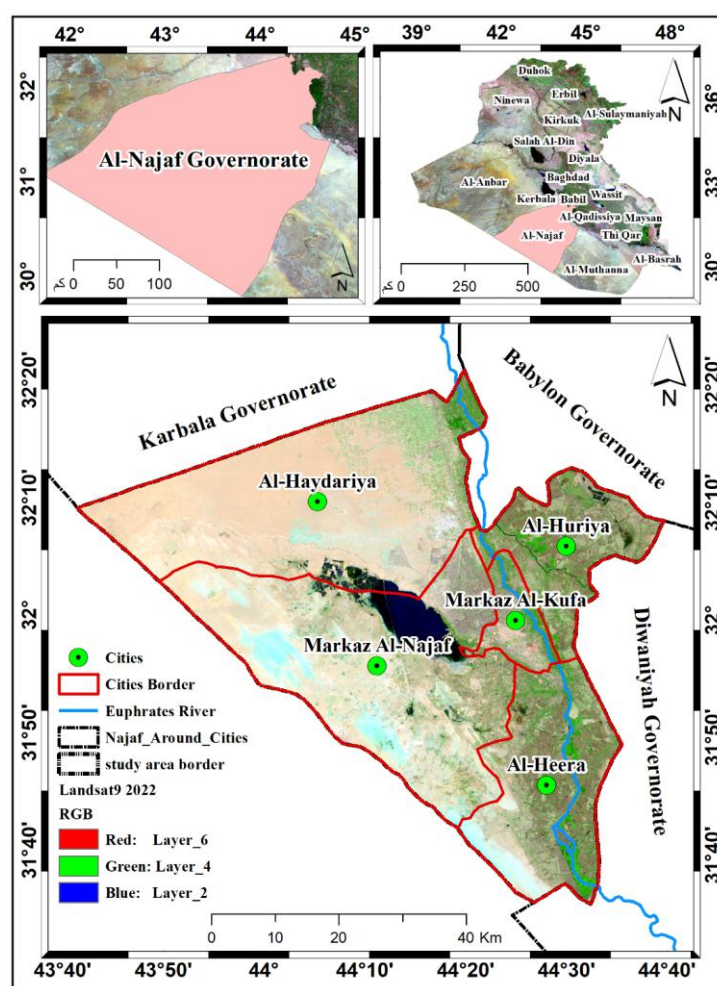

Figure (1) The spatial borders of the study area

Materials and methods

Data and tools

In this study, the Landsat 8 and 9 satellite images were utilized for the years 2014 and 2022, and for two seasons, which are the spring season, represented by the March satellite images, and the autumn season, represented by the September satellite images Table (1). The Landsat 8 and 9 satellite images of were obtained from the US Geological Survey website (https://earthexplorer.usgs.gov/).

Table (1) Characteristics of Landsat satellite images used in this study

Year	Season	Acquisition date	Satellite	Sensors	Path	Row
2014	Spring	February 26, 2014	Landsat 8	OLI	169	38
		March 23, 2014			168	
	Autumn	September 15, 2014			168	
		September 22, 2014			169	
2022	Spring	March 4, 2022	Landsat 8	OLI	169	38
		March 13, 2022			168	
	Autumn	September 28, 2022	Landsat 8	OLI	169	
		September 29, 2022	Landsat 9	OLI-2	168	

Methodology

The methodology of this study included digital images processing of Landsat 8 and 9 satellite through the use of the NDVI, which is one of the most important spectral indices used in monitoring vegetation cover, and it can be calculated through the following equation [12]:

$$NDVI = \frac{NIR\ Band - R\ band}{NIR\ Band + R\ band} \quad ......1$$

The values of the vegetation index range between -1 and 1, as the positive values indicate the presence of vegetation cover, and the higher values indicate the density and health of the plant, while the negative values indicate the rest of the land cover classes [13, 14].

In order to detect changes in the vegetation cover, it has relied in this study on the use the change detection tools that were developed by [15], which specialized in detecting changes in the vegetation cover and work within the ArcGIS environment. This tool depends on the method of difference in the results of the NDVI vegetation index for two different time periods, which will produce a thematic map with numerical values confined between =2 to +2. The map units that approach positive values indicate areas of increased vegetation until they reach the largest value. Which is +2, which represents the areas in which the largest increase in vegetation cover occurred, while negative values will indicate the areas in which a decrease in vegetation cover occurred until it reaches the largest negative value, which is -2, which represents the areas in which the largest decrease in vegetation cover occurred. This increase or decrease in the vegetation cover will require calculating its area, and this can't be done without reclassifying the resulting change detection map and then calculating the area of each class on this map, which was reclassified into five varieties using the method of equal classes centered around a central point. The final output of this developed tool will be two maps and one table, the first map will represent the change layer with values confined between -2 and +2, and the second output will represent a thematic map divided into five classes showing the spatial distribution of change within the study area, while a table is showing the automatic calculation of an area for each class.

Results and discussion

Interpretation of the NDVI results

Figure (2) shows the NDVI results of the spring and autumn seasons for the years 2014 and 2022. The positive values or white color indicate the spread places of vegetation, either negative values or dark areas (gray or black) refer to vacant areas of vegetation. Figure (3) shows the result of extracting the vegetation cover from the NDVI at a threshold of 0.1 of the NDVI value using ArcGIS 10.8.

The spatial spread of vegetation covers within the study area as shown in Figure (3) indicates that the vegetation cover is concentrated in the eastern side of the study area on the banks of the Euphrates River and its branches, while the central or western regions are devoid of vegetation, which is a natural result because the western areas have no water sources. In the central region, despite the presence of the largest water body represented by the Najaf Sea, with the spread of many small seasonal lakes sometimes, the water of these lakes is salty water due to the spread of many salt deposits with the low level of the land in this area, thus making it unsuitable for agricultural activity.
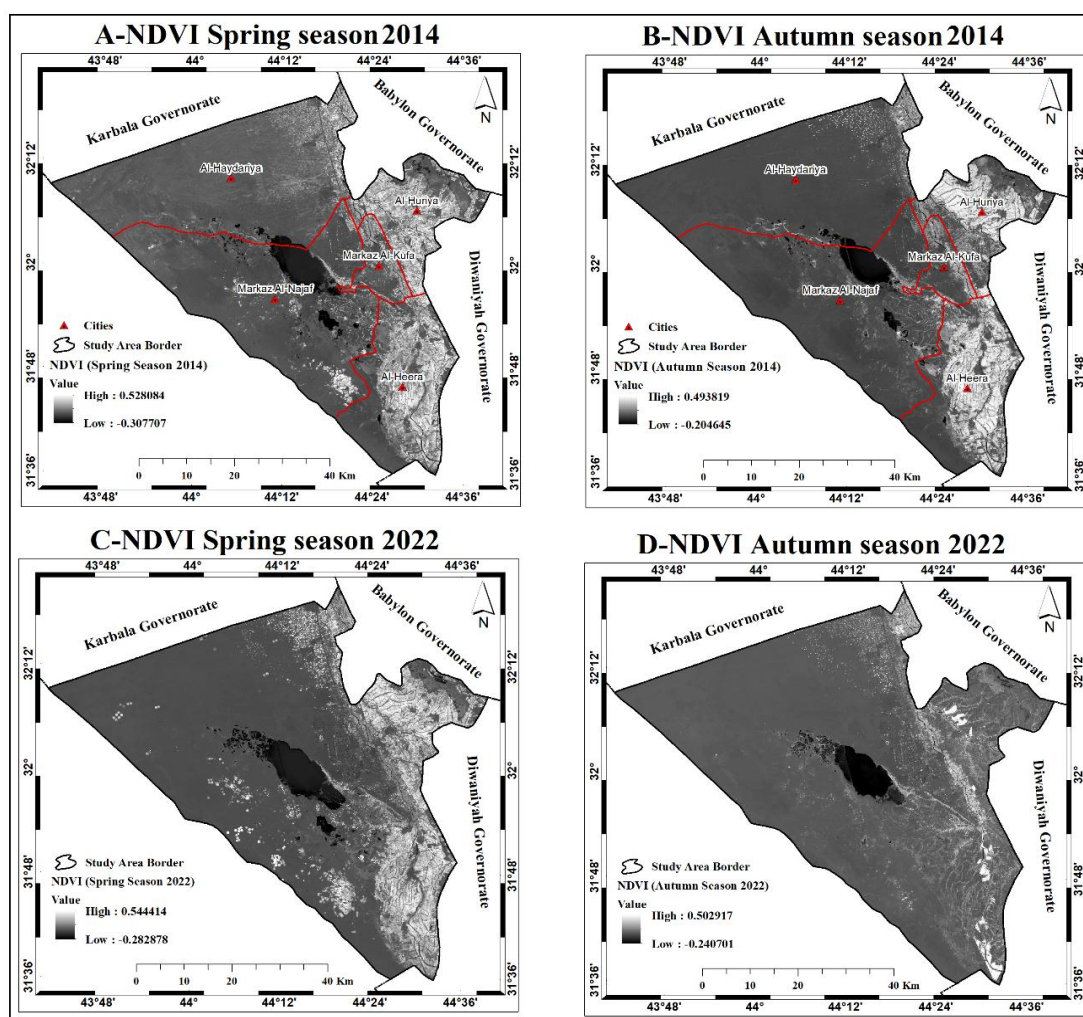
Figure (2) NDVI of the spring and autumn seasons for the years 2014 and 2022

Table (2) shows the lower and upper values of the NDVI with the calculated area of vegetation cover, while Figure (4) is a chart showing the comparison between the areas of vegetation cover for the spring and autumn seasons and for the years 2014 and 2022. The average of the highest values of the NDVI was

0.52, which is a normal value indicating that the study area has a vegetation cover of medium density and that the study area is free of dense forests. The highest value of the NDVI was in the spring of 2014 (0.58), which indicates the density of vegetation cover in this season with an increase in the area of the cover, as it occupied an area of 1200 km^2, which represented 33% of the study area.

In general, the values NDVI may not reflect the area of the vegetation cover as much as they indicate the density of the cover and the high percentage of chlorophyll in the plants. In terms of area, the highest areas of vegetation cover were in the spring of 2014 and spring of 2022, while the lowest areas of vegetation were in the autumn of 2022 and spring of 2007.
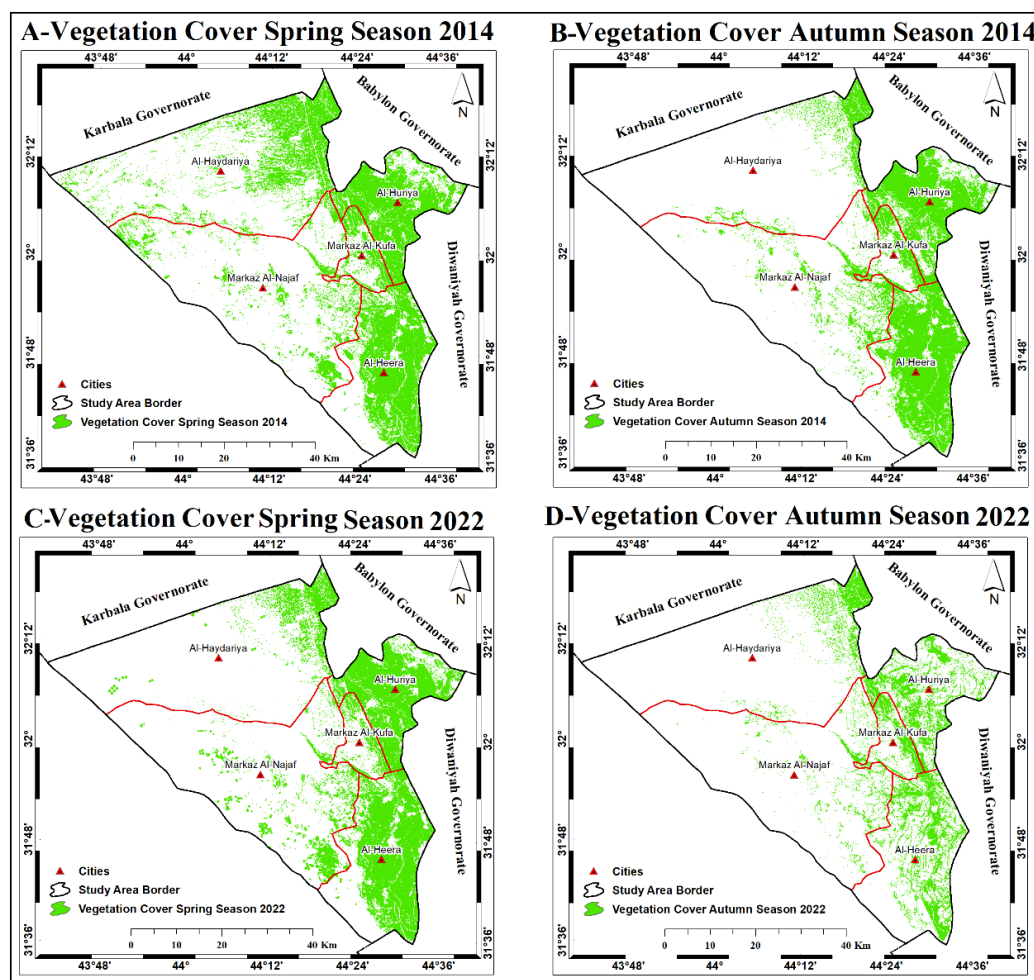

Figure (3) Extracted vegetation cover of the spring and autumn seasons for the years 2014 and 2022

Table (2) The lower and upper values of the NDVI with the area and percent of vegetation cover

Year	Season	Highest NDVI values	Lower NDVI values	Vegetation Cover Area Km^2	Vegetation Cover Area %
2014	الربيع	0.581	-0.307	1200	33
	الخريف	0.494	-0.205	963.4	27
2022	الربيع	0.544	-0.283	983	27
	الخريف	0.503	-0.241	534	15
	المعدل	**0.52**	**-0.27**		
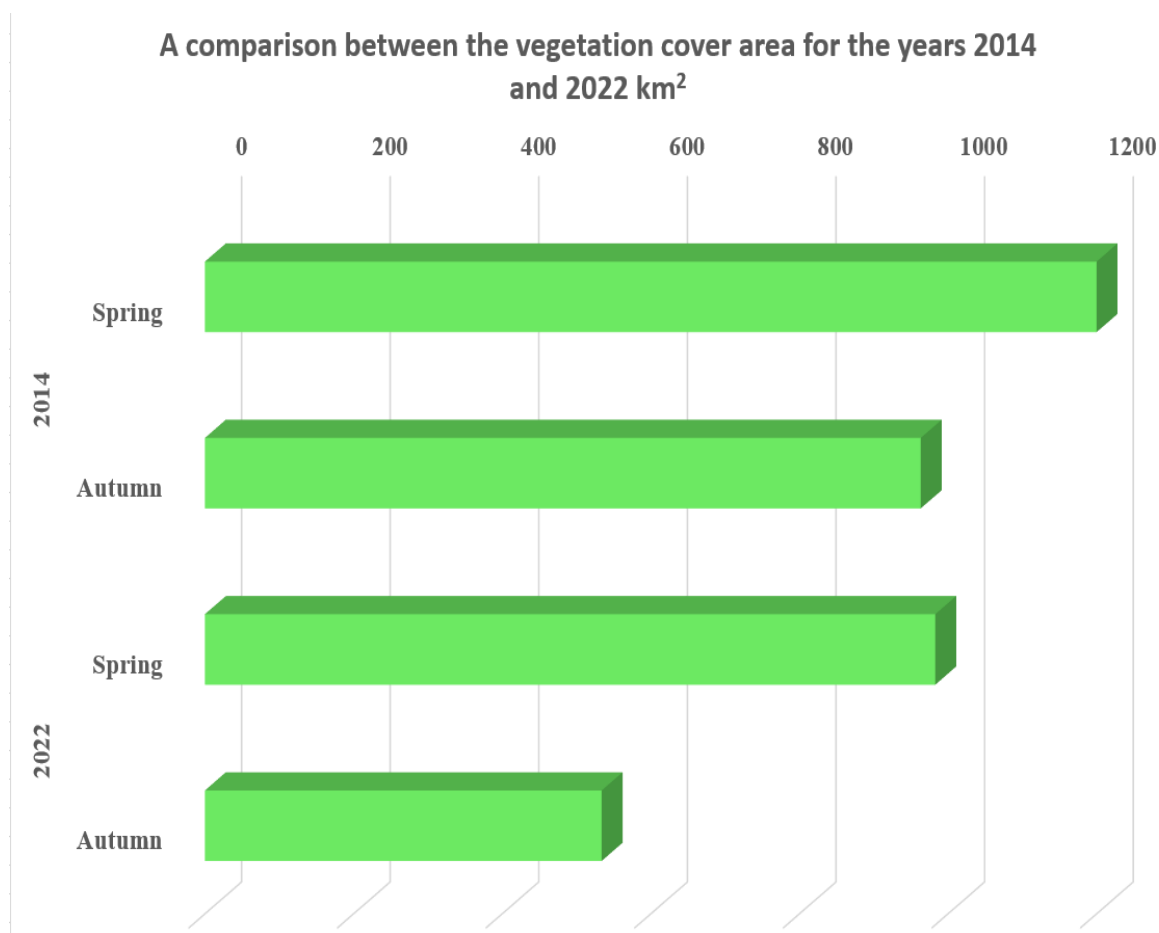
Figure (4) A comparison between the areas of vegetation cover for the spring and autumn seasons and for the years 2014 and 2022.

Analysis and detection of vegetation cover changes

1- Changes detection at the seasonal level

Figures (5) and (6) represent the change detection maps of the vegetation cover between spring and autumn for the years 2014 and 2022, respectively, through which the spatial distribution of changes can be observed. Table (3) shows the calculation of the areas for detecting the change in the vegetation cover between the spring and autumn seasons for the years 2014 and 2022, respectively. The vegetation cover changes for the year 2014 show that there is a clear concentration of decreased areas east of the study area (red color east of Kufa city) and east of Al-Haydaria city, Figure (5). As for the vegetation cover changes in the year 2022, there was a severe decrease and a significant deterioration of the vegetation cover along the east of the study area (almost most of Al-Huriyah city and the Al-Hira city in the southeast) through the spread of the red color in Figure (6). The change in the vegetation cover in the year 2014 was the highest compared to the year 2022, as the area of land that was not changed was estimated at 2628 km2 (about 73% of the area of the study area) in the year 2022, while in the year 2014, the area of land that was not changed was 2269 km2 (About 63% of the study area, Table (3) and Figures (5 & 6)
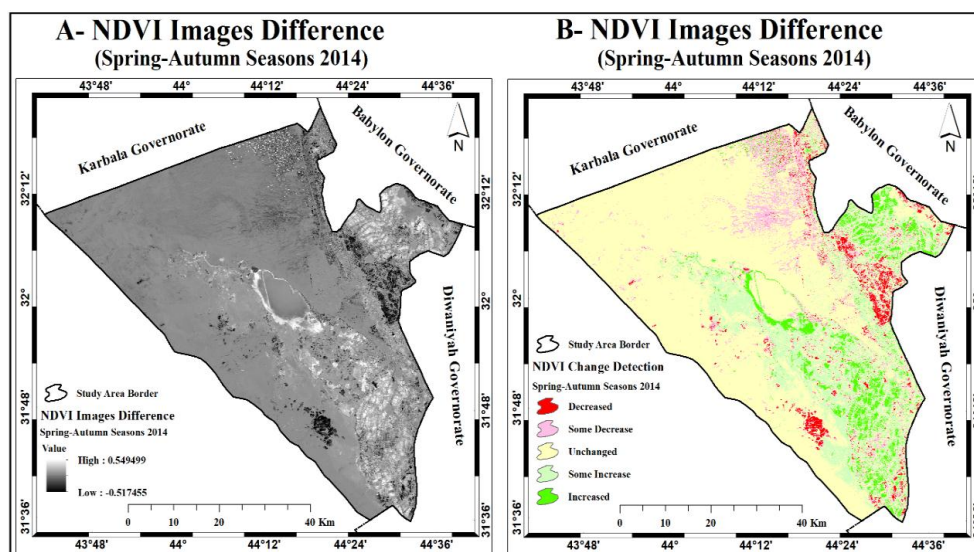
Figure (5) Change detection in the vegetation cover between Spring and Autumn 2014
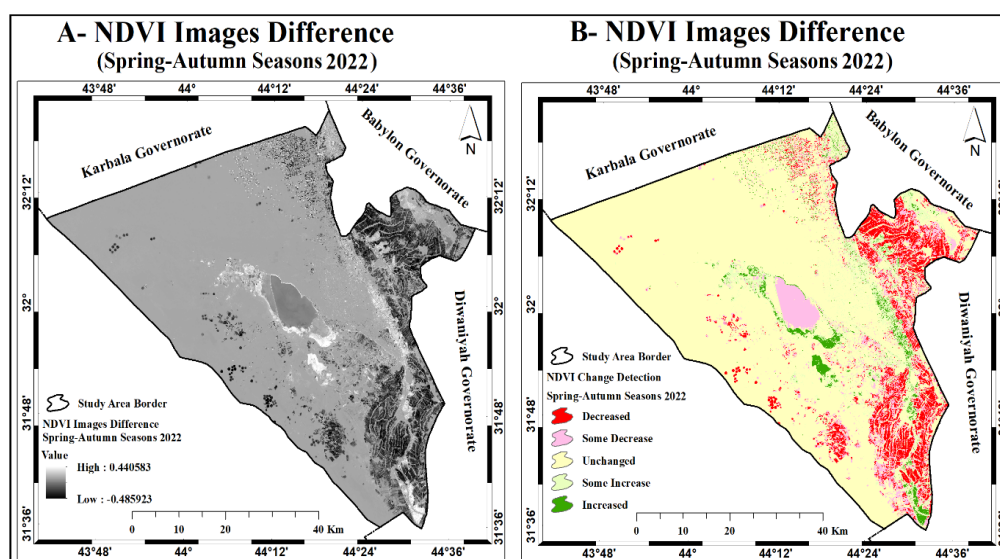

Figure (6) Change detection in the vegetation cover between Spring and Autumn 2014

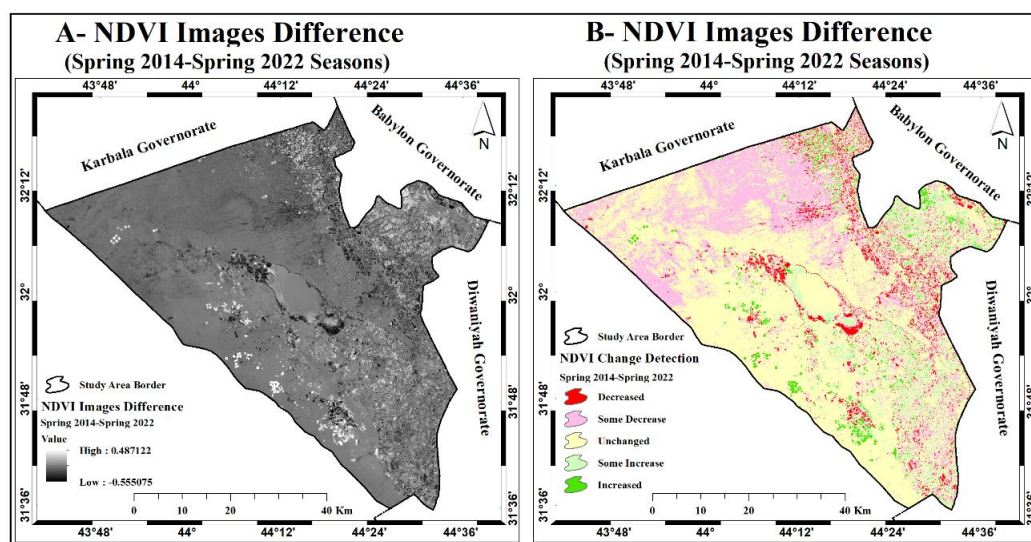**Table (3) Area changes of vegetation cover for the years 2014, 2022**

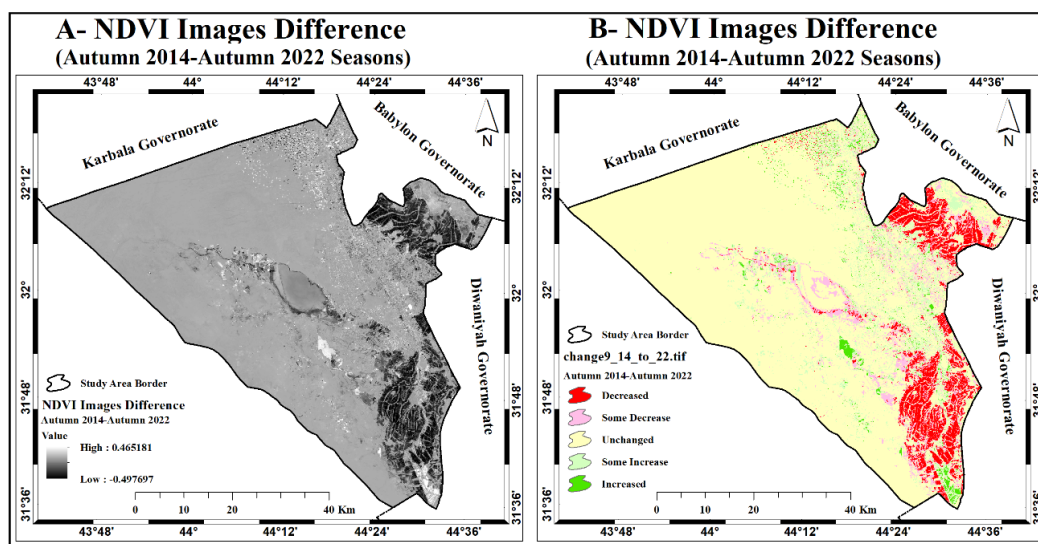|	Increase Km^2	Some Increase Km^2	Unchanged Km^2	Some Decrease Km^2	Decrease Km^2
Spring-Autumn Seasons 2014	203.0	690.4	2269.0	330.9	100.7
Spring-Autumn Seasons 2022	80.5	214.2	2628.0	358.8	312.5

2- Changes detection at the yearly level

The vegetation cover changes were analyzed at the annual level by comparing the results of the NDVI for two time periods: spring 2014-spring 2022, and autumn 2014-autumn 2022. Figures (7) and (8) represent the vegetation cover changes between the spring season for the period 2014-2022, and between the

autumn season for the period 2014-2022, respectively. The figures show the spatial distribution of vegetation cover changes within the study area. Table (4) shows the calculation of the area of change in the vegetation cover for the period 2014-2022 and for each of the spring and autumn seasons.

The most variable period for vegetation cover was the period between spring 2014 and spring 2022 when the land cover that remained unchanged reached 1968 km2, or 54% of the study area. As for the period during the autumn 2014-autumn 2022, the periods were the least changed in terms of vegetation cover, as the area of land that did not change in vegetation cover reached 2731.9 km 2, with percentages reaching 76% of the area of the study area. The results of the vegetation cover changes also indicated that the changes during the spring season were higher than the changes during the autumn season. Perhaps the most important reasons for this are that the dryness of the lands and the lack of rain in the months preceding the fall season lead to a decrease in the area of vegetation cover in the autumn season compared to the vegetation cover in the spring season.

Figure (7) Change detection in the vegetation cover between the Spring of 2014 and the Spring of 2022

Figure (8) Change detection in the vegetation cover between the Autumn of 2014 and the Autumn of 2022

Table (4) Area changes of vegetation cover for the years 2014, 2022 at yearly level

Season change	Increase Km^2	Some Increase Km^2	Unchanged Km^2	Some Decrease Km^2	Decrease Km^2
Spring 2014- Spring 2022	96.5241	340.613	**1968.23**	1011.45	177.153
Autumn 2014- Autumn 2022	55.0125	241.898	**2731.96**	285.242	279.861

Conclusions

1. Remote sensing techniques and geographic information systems are among the advanced techniques that have been used a lot in classifying vegetation in order to identify its characteristics and geographical distribution. This integration between geographic information systems with remote sensing techniques will give quick results that have high accuracy with little cost and less effort compared to traditional methods.

2. The spatial spread of vegetation covers within the study area indicates that the vegetation cover is concentrated in the eastern side of the study area on the banks of the Euphrates River and its branches, while the central or western regions are devoid of vegetation.

3. The average of the highest values of the NDVI was 0.52, which is a normal value indicating that the study area has a vegetation cover of medium density and that the study area is free of dense forests.

4. The vegetation cover changes show that there is a clear concentration of decreased vegetation areas along the east of the study area.

5. The results of the vegetation cover changes also indicated that the changes during the spring season were higher than the changes during the autumn season. Perhaps the most important reasons for this are that the dryness of the lands and the lack of rain in the months preceding the fall season lead to a decrease in the area of vegetation cover in the autumn season compared to the vegetation cover in the spring season.

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